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50G PON System

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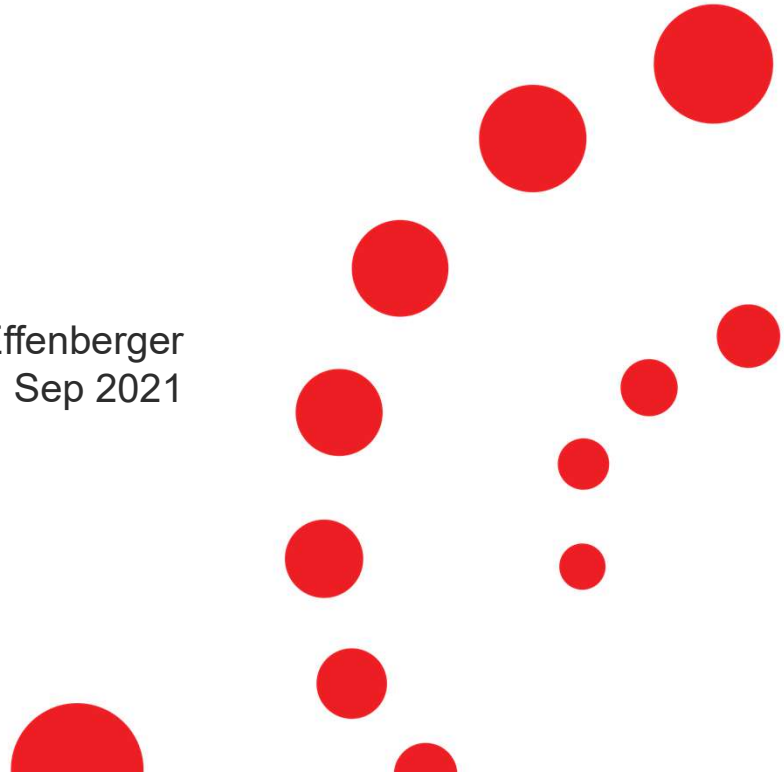
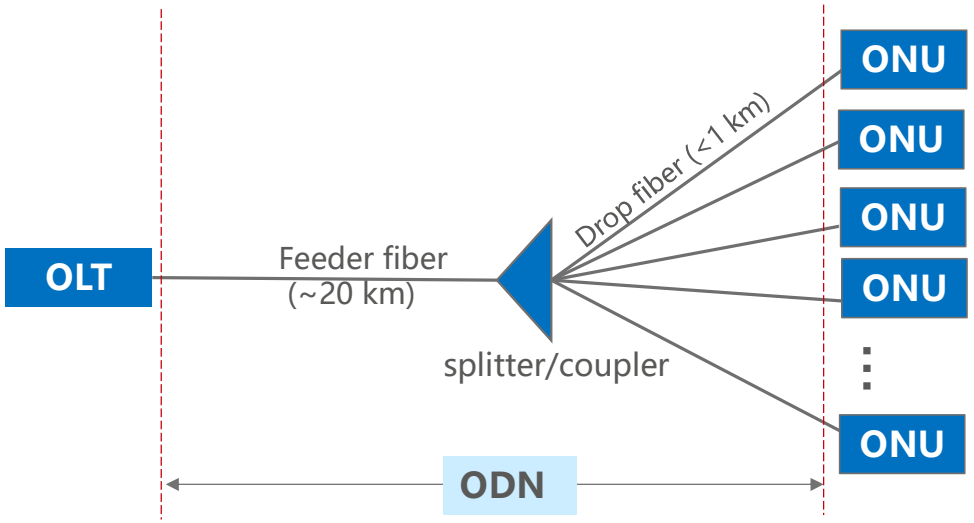
Sep 2021



Passive Optical Network (PON) basics



- OLT: optical line terminal, PON central office element
- ONU: optical network unit, PON user premise element
- Splitter/coupler: 1:n optical splitter in downstream and n:1 optical coupler in upstream, PON remote node element
- ODN: optical distribution network, PON contains a point-to-multipoint (PtMP) passive distribution network as the outside plant

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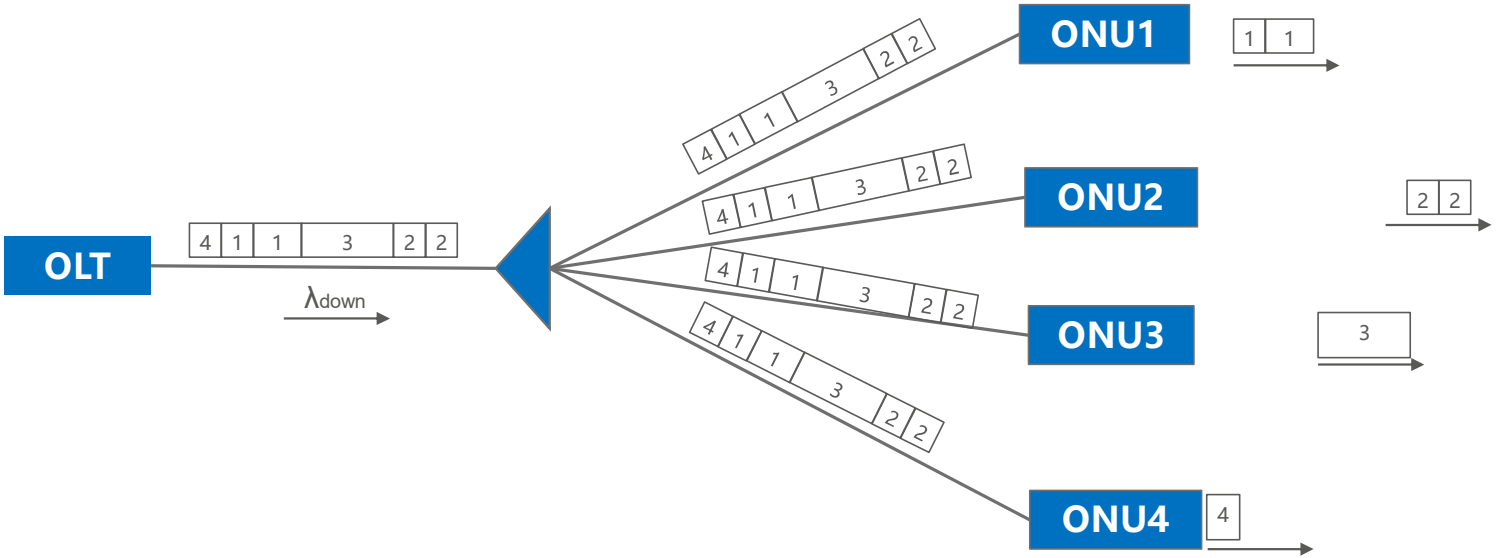
Downstream TDM mode



- One wavelength is employed for downstream transmission, remote note works as splitter
- OLT traffic is broadcast to all ONUs
- An ONU selects traffic destined to itself and forwards traffic for further processing

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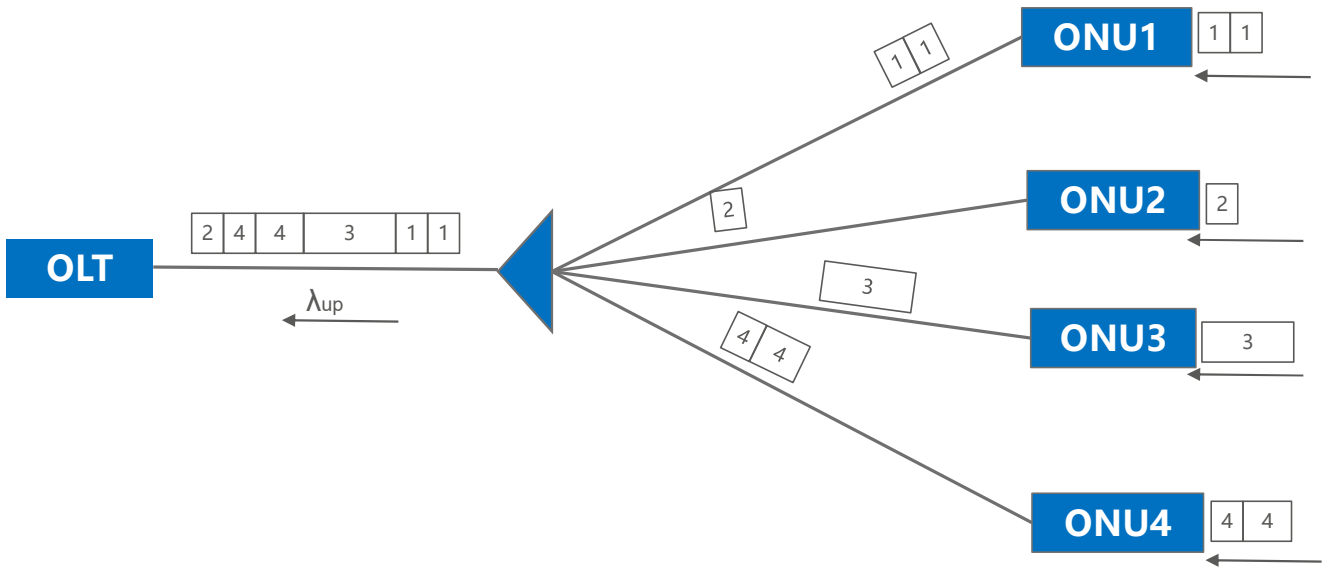
Upstream TDMA mode



- Another wavelength is employed for upstream transmission
- Remote node works as coupler in upstream
- The OLT schedules ONU transmission timeslots to avoid collision
- Each ONU transmits traffic to the OLT in bursts

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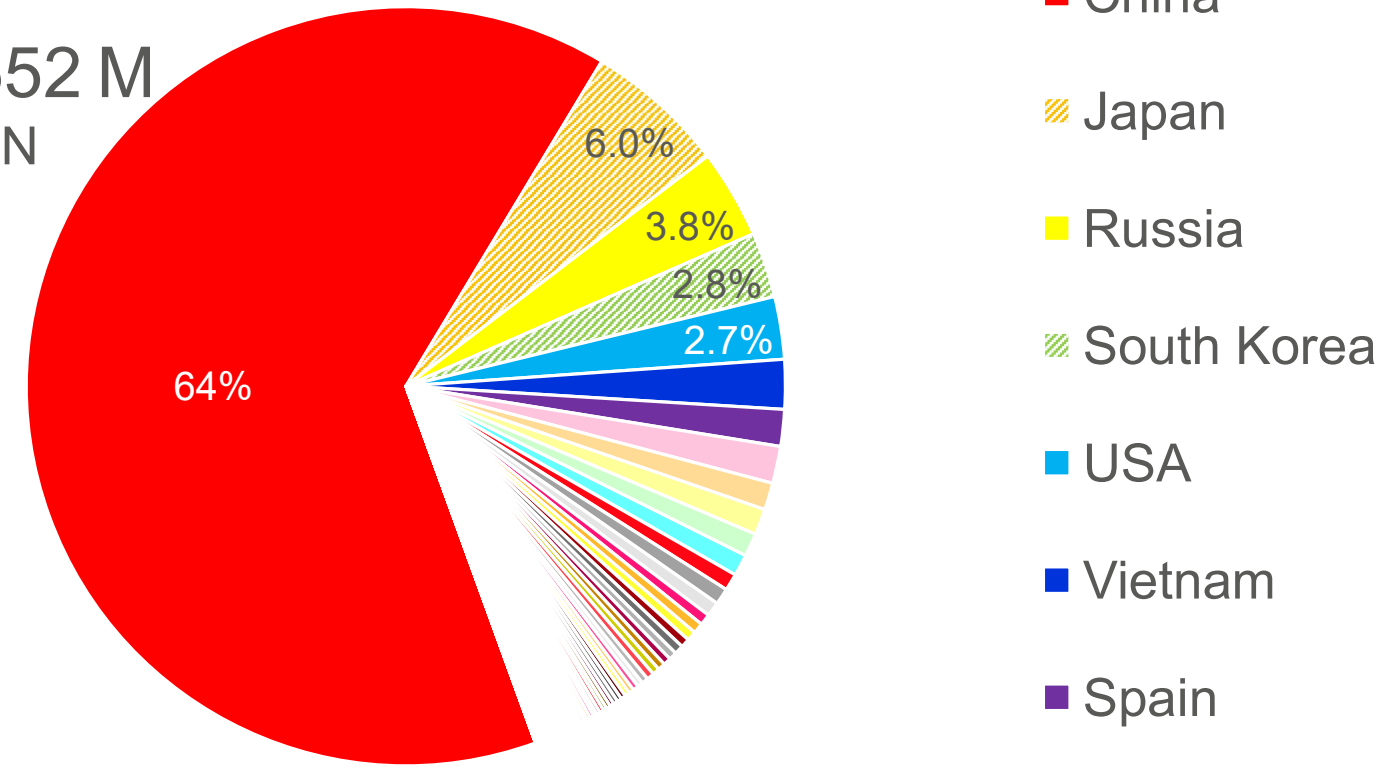
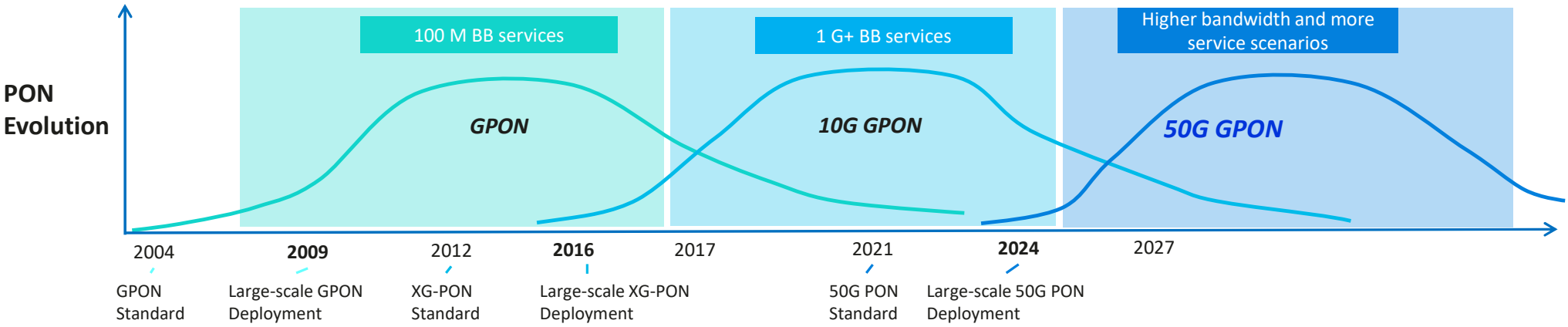
FTTx subscribers broken down by country

Total FTTx sub = 652 M
Vast majority is PON



Data courtesy of Informa Telecoms & Media Ltd.

The access network upgrade cadence



- The operators that deployed most of the PON in the world have clear requirements
  - Access network deployment pace is 8 to 10 years. Going any faster cannot be supported economically or operationally
  - Bandwidth must be upgraded by at least 4 times. Anything less than this is not worth the cost and effort
- 50G-PON is technically achievable in the required time
  - Majority system will be 50G down / 25G up
  - The introduction of DSP and soft FEC brings large improvements
  - Given the ~4 years before significant volume, we have the time

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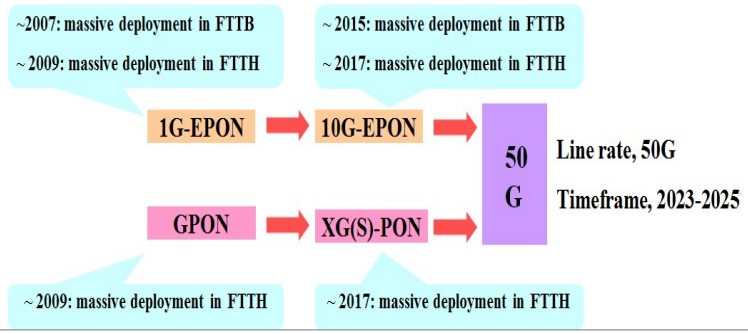
See what the Chinese operators say about it

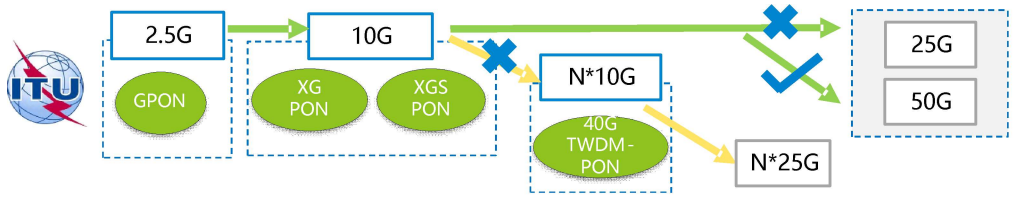
China Telecom & China Unicom

- 10G PON is under massive deployment in China
- Massive deployment of next generation PON may happen 7-8 years later
- Considering the time period for standardization and industry maturity, at least 1-2 years left to analyze the feasible solutions and choose the best way forward

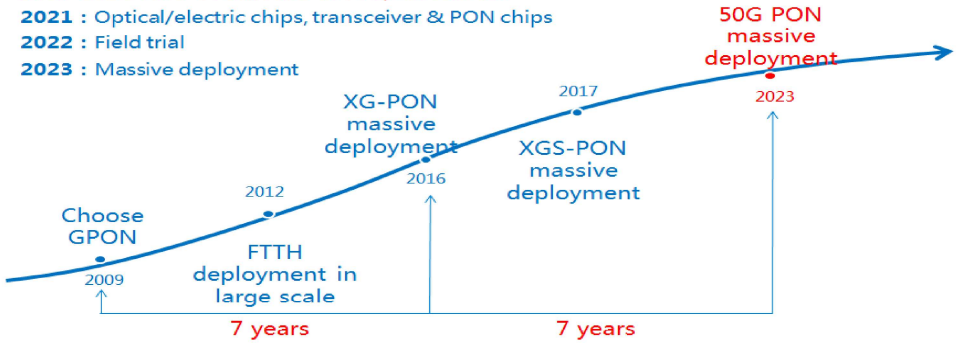


China Mobile

Cost in PON is sensitive; BW increased by 4 times per generation.
50G PON is preferred candidate technology.



Expected Schedule
2019-2020 : ITU-T REQ, PMD & TC spec. consent
2021 : Optical/electric chips, transceiver & PON chips
2022 : Field trial
2023 : Massive deployment



- 50G TDM-PON will be the next step after 10G in 2023~2025 timeframe

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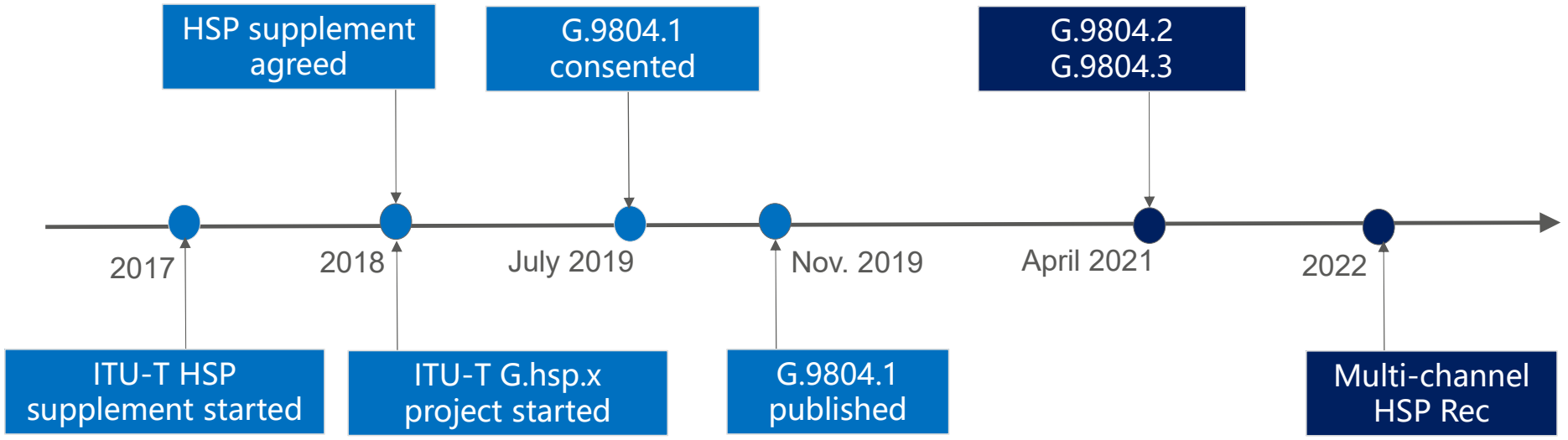
50G-PON Standards Timeline



- ITU started 50G-PON standardization work from 2017
- A supplement (G.sup.64) on candidate technologies was published in 2018
- 50G-PON system requirement recommendation (G.9804.1) was published in 2019
- 50G-PON PHY and MAC recommendations are mature and to be consented in April 2021

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G.9804.1: Higher speed PON requirements

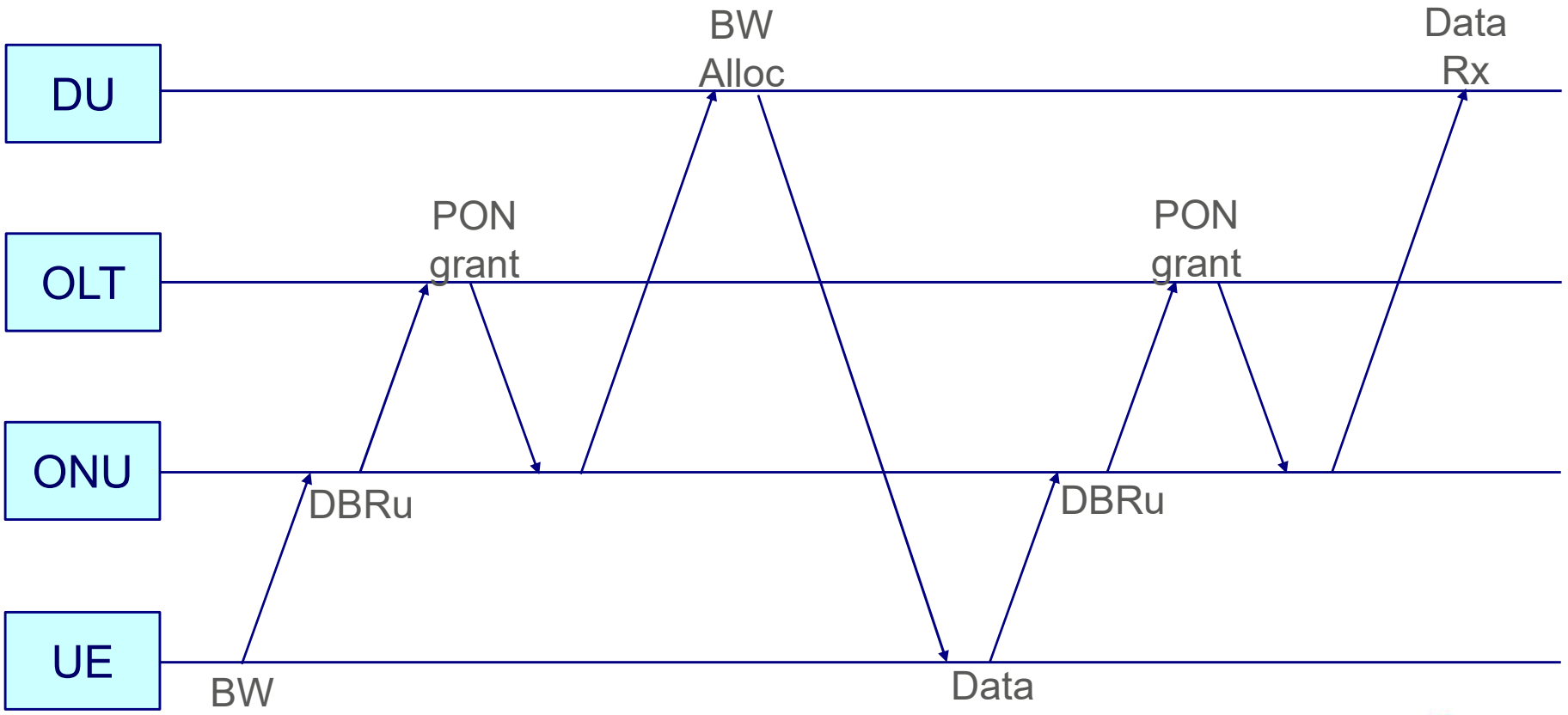
- Higher speed PONs share many requirements with existing systems
  - Must reuse the fiber plant based on splitters and G.652 fiber
  - Must support the same loss budgets and distances
  - Must coexist with existing systems in a passive way
- System must have 50 Gb/s per channel downstream
  - The current deployment of 10G systems means that the HSP system will be deployed in 2024, and must have at least 4x capacity of the 10G system
  - The upstream can be a lower rate, 25 Gb/s looks attractive
- G.9804.1 was approved in Dec 2019, and amended Apr 2021

G.9804.2: Higher speed Common TC

- The common TC is intended to be used for PON 50G and up
- It is largely based upon XGS-PON protocol constructs, with enhancements
  - A better LDPC FEC code, which allows raw BER of 1e-2 or more
  - Interleaving to further condition burst errors
  - Allowance for contention-based transmission for efficient low latency signaling
  - Cooperative DBA, so that bursty low latency services can be supported
  - Better transport security with longer keys and multiple algorithms
  - Multiple upstream rates, allowing for link budget adaptation

- G.9804.2 was consented in April 2021

The problem of fronthaul over PON



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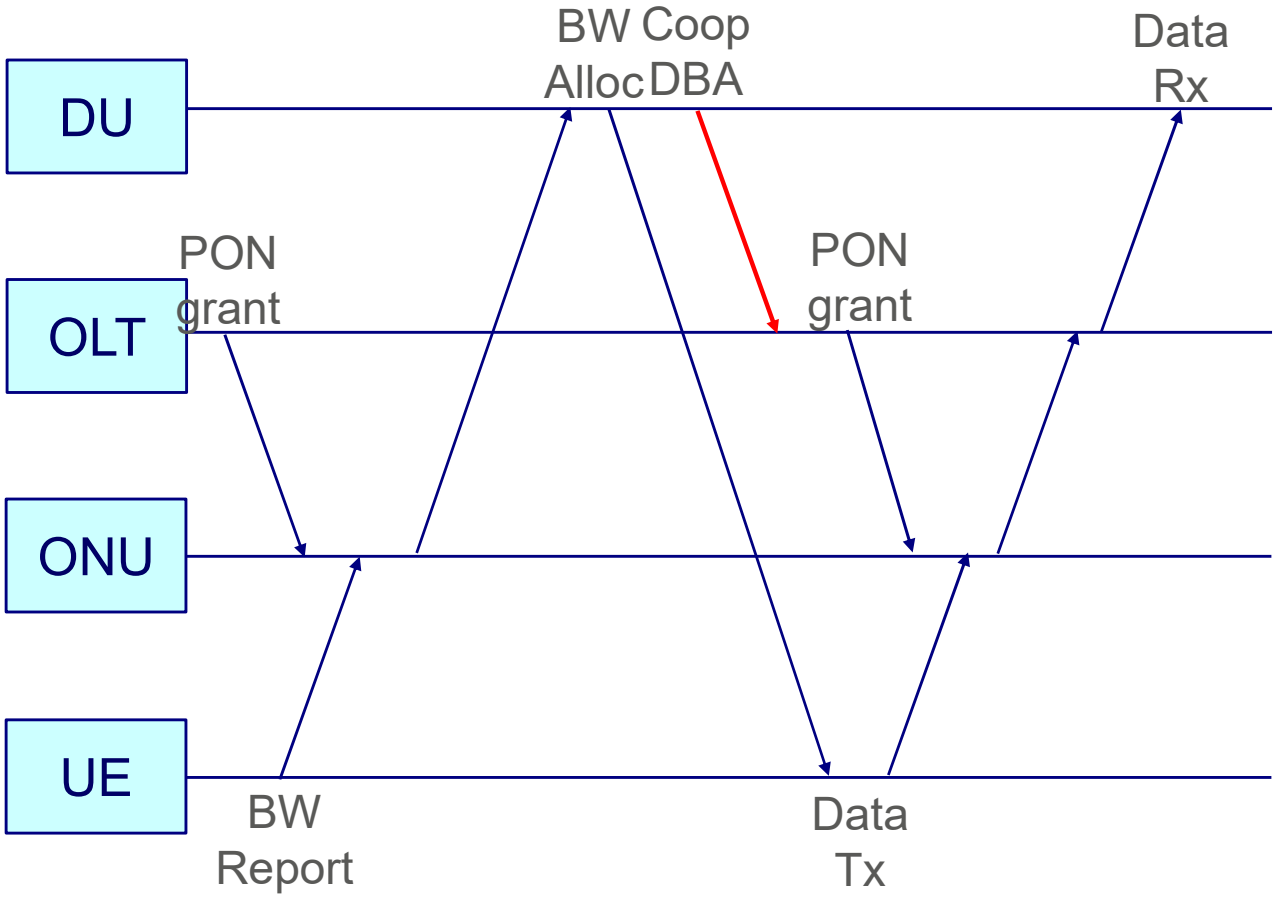
Cooperative DBA: How to run a MAC within a MAC



- Q2 has made additions to the TC layer to add delay and jitter requirements
- This gives guidance on how to build a DBA engine with proper controls
- In April, a supplement document was agreed

- ORAN alliance is working on the specification of the Cooperative Transport Interface
- This develops all the protocol elements needed to communicate with the OLT

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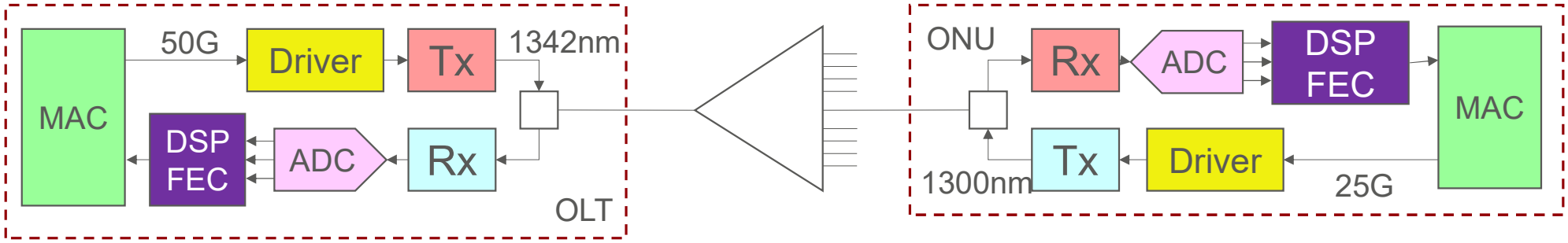
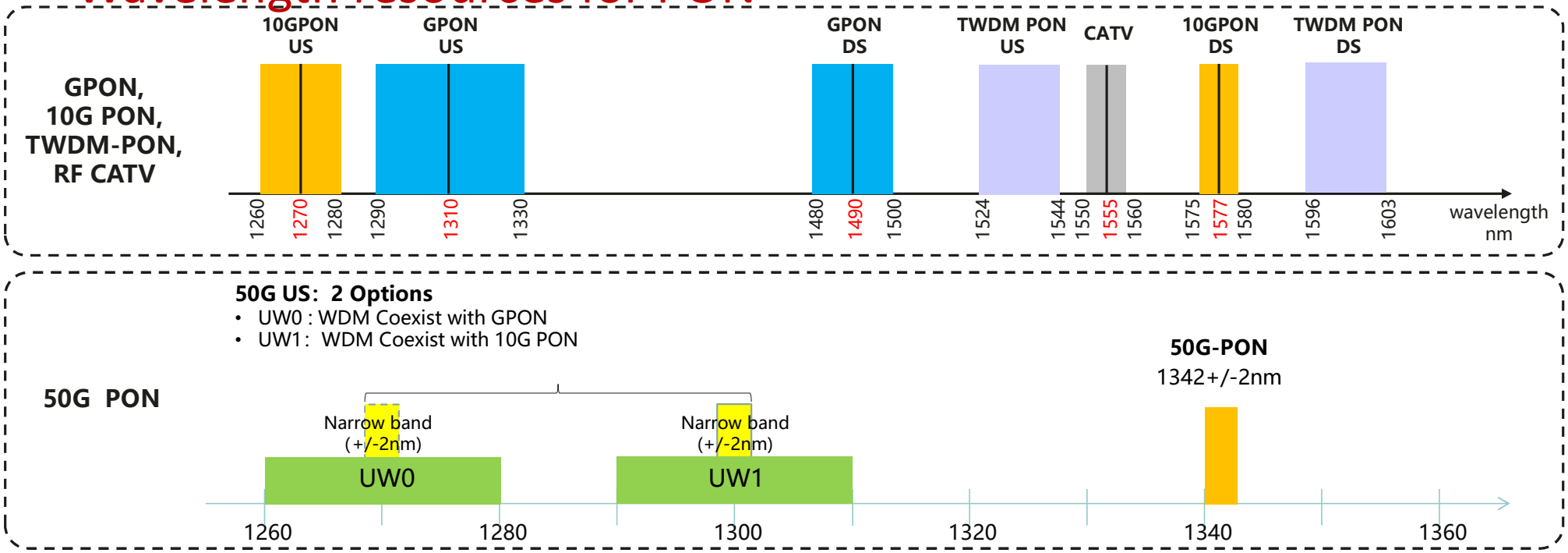
G.9804.3: Specifications of fixed 50G PMD



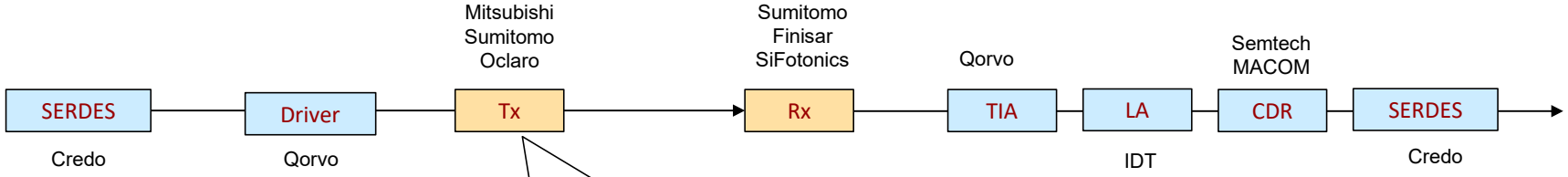
- Single channel system for low cost overall
- Simple way to reach 50G loss budget: Use a stronger Tx at the OLT
- Use DSP in both directions for equalization, burst mode reception, low density parity check (LDPC) code with soft decoding for high sensitivity, and flexible rate decoding for link budget elasticity
  - Once we have an ASIC, its cost quickly tends to zero with 100M volumes
- Wavelength plan reuse of 802.3ca and coexistence with either G-PON or XG-PON
- G.9804.3 was consented in April 2021

Wavelength resources for PON



- The upstream wavelengths in PON are 1270nm and 1300nm due to low fiber dispersion
- Currently, 10G PON uses the 1270nm wavelength band and GPON uses the 1310nm wavelength band
- 50G PON has UW0 (1270 nm) and UW1 (1300 nm) options, so it can coexist with either GPON or XG-PON

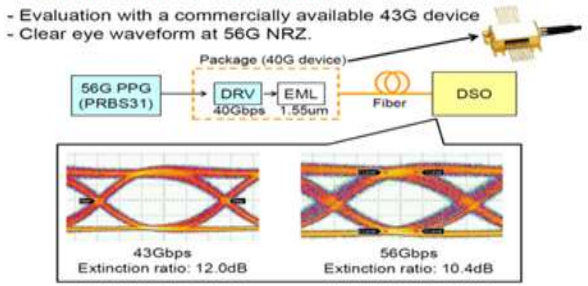
50Gb/s technology and component availability

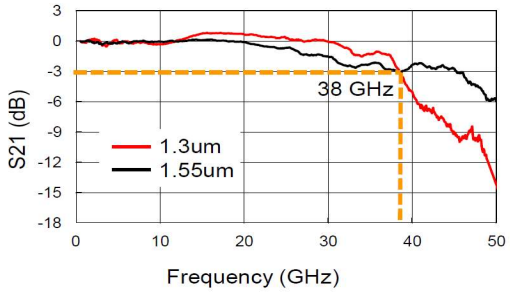


Many 25/50G EML vendors
20 – 50GHz bandwidth
7 – 10dB ER
0 – 8dBm (high power with SOA)

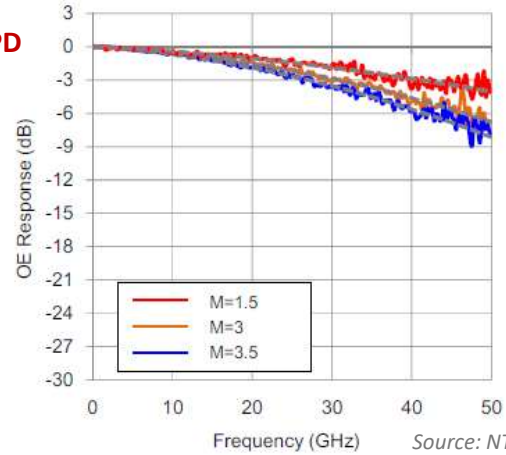
40/50G EML

- Evaluation with a commercially available 43G device
- Clear eye waveform at 56G NRZ.





50G APD



Source: NTT OFC 2018

50G optical and electrical components vendors						
Lasers	Rx	Limiting Amplifier	CDR	TIA	SERDES	Laser Driver
Mitsubishi, Sumitomo, Oclaro	Sumitomo, Finisar, Siphotonic, NTT device	Qorvo	Semtech MACOM	IDT	Credo	Qorvo

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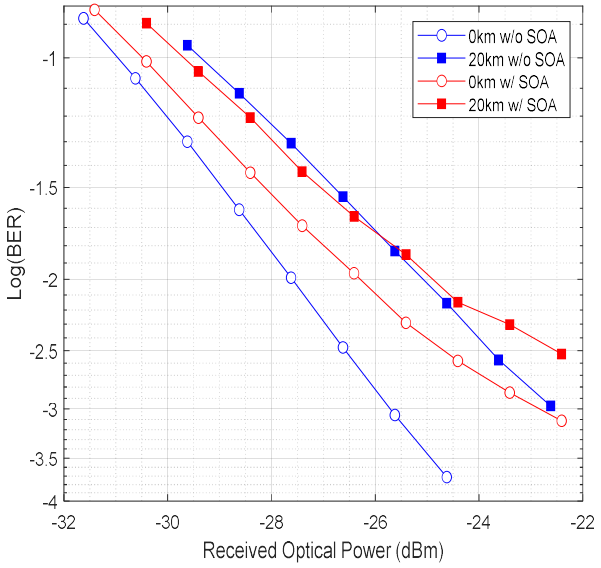
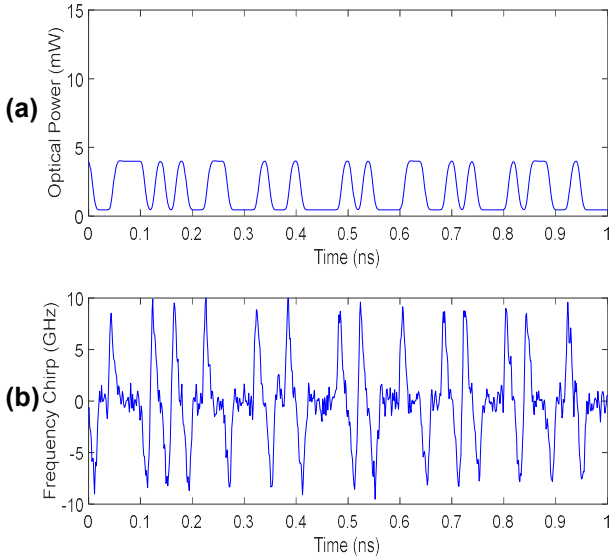
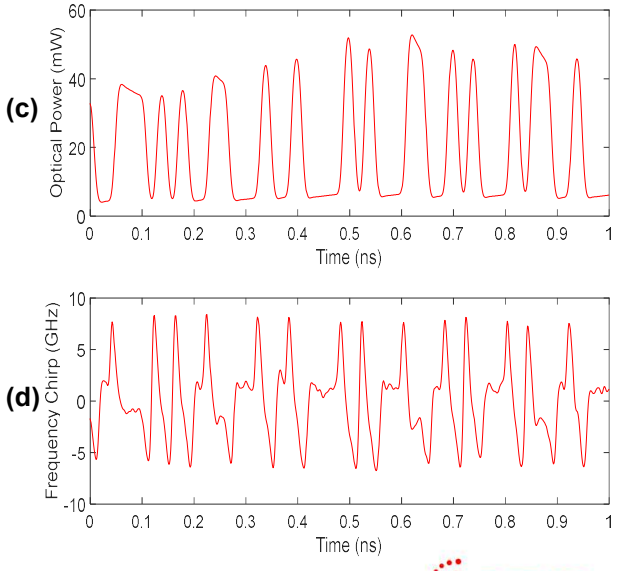
50G downstream enabled by chirp managed transmitters

- By controlling the bias conditions of the OLT post-amp SOA, large improvements in dispersion penalties can be made
  - The SOA is killing two birds with one stone







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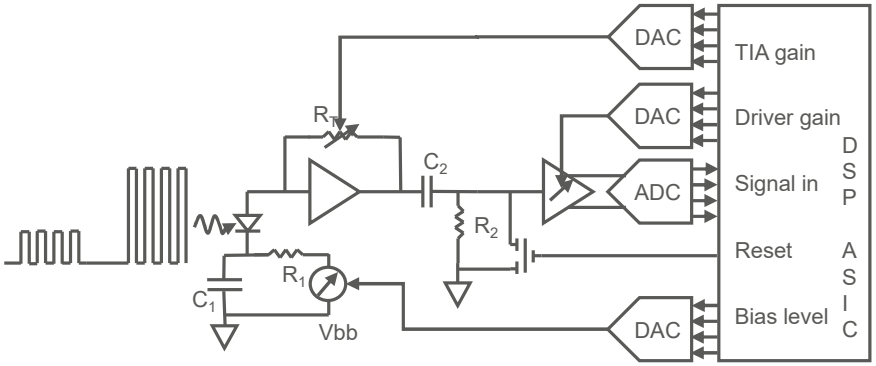
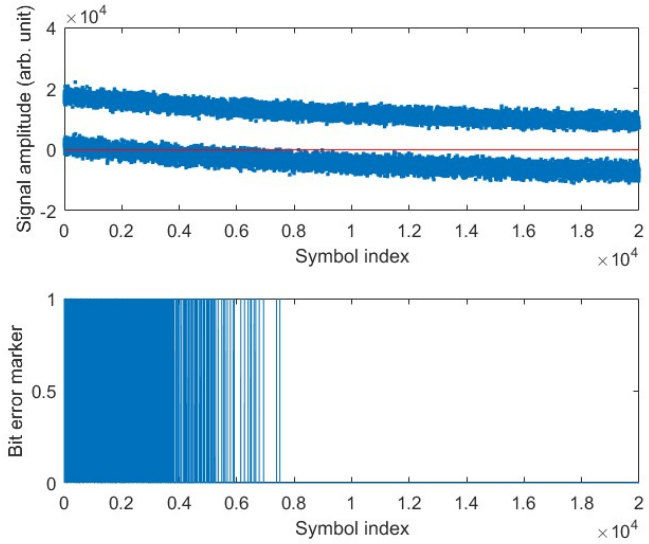
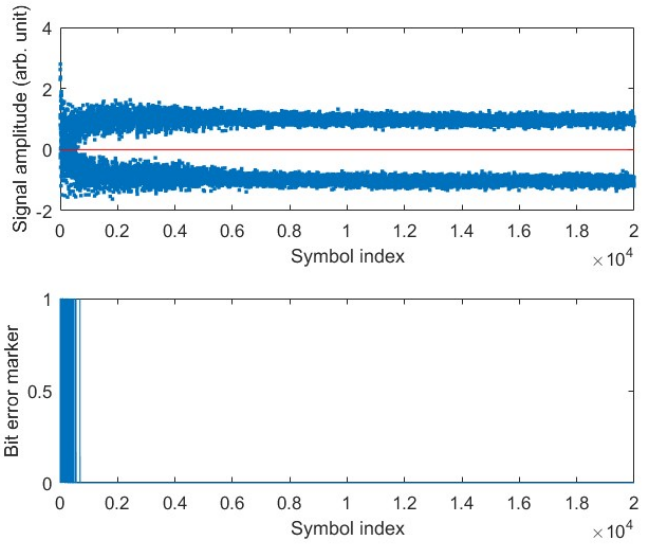
DSP improves performance and enables soft FEC seamlessly







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Thank You.